Comparison of Respiration Losses in Intensively Conditioned and Unconditioned Alfalfa

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Introduction

Intensive conditioning of forage crops has several advantages: (1) accelerated drying rates, (2) increased fiber digestibility, (3) improved protein utilization, and (4) improved fermentation characteristics. Under good drying conditions, macerated alfalfa dried to 20% moisture (w.b.) in 6 h or less. Reaching good moisture contents (45 to 65%) for ensiling requires only 1 to 3 h of drying. With such short wilting periods, respiration losses are not a concern. However, when the wilting period is extended, due to unfavorable weather conditions or by mowing late in the evening, the forage will remain in a moist, aerobic environment for an extended period of time. Several studies indicate that a direct correlation exists between respiration rate and conditioning level of forage. Therefore, the question arises as to whether severely conditioning the forage leads to excessive respiration losses.

Under aerobic conditions, plant respiration causes the oxidation of hexose sugar to carbon dioxide and water. The stoichiometric relationship is: $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$ + 2870 kJ/Mole. Therefore, measurement of CO_2 output will enable the estimation of dry matter consumed during aerobic respiration.

Procedure

Figure 1 is a schematic of the apparatus used to measure the rate of CO_2 production from forage samples. The apparatus consisted of 6 components: a tank of compressed dry-air, an air flow regulator, a respiration chamber, a desiccant, an air mass-flow meter, and a mass spectrometer. Four respiration chambers were fabricated allowing multiple runs to be performed simultaneously.

Severely conditioned and unconditioned fresh alfalfa samples, approximately 1000 g each, were placed into the respiration chambers and allowed to respire for 48 h. Dry air was metered through the chambers to maintain an aerobic environment inside each chamber. The mass flow rate of the air and the concentration of CO_2 entering and exiting each chamber was measured at 15 min. intervals. This allowed the rate of CO_2 production to be determined.

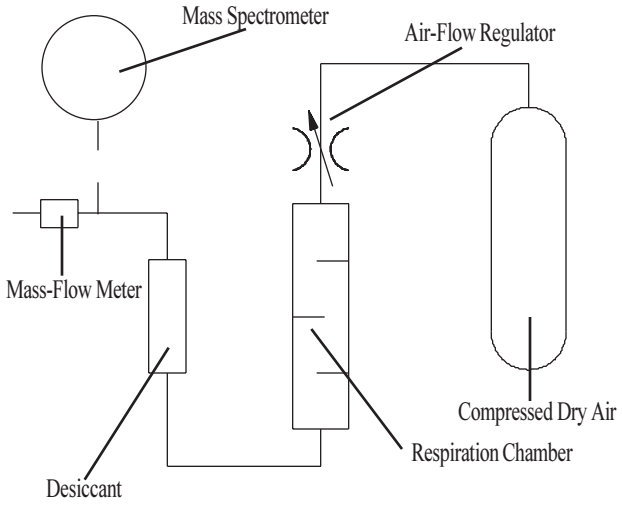

Figure 1. Respiration Apparatus.

Results

Production rates of CO_2 of severely conditioned and unconditioned fresh alfalfa at 31 °C are shown in Figure 2. The respiration of CO_2 from the unconditioned sample steadily decreased throughout the respiration period. However, the respiration of CO_2 from the severely conditioned material was different. During the first 8 h, the respiration rate of CO_2 of the severely

conditioned forage was lower than that of the unconditioned forage. However, after this initial lag phase, the production of CO_2 increased rapidly to approximately 2 times that of the maximum rate of the control.

Respiration losses of the stored carbohydrates and plant sugars occur for two reasons. First, undamaged cells continue to respire even though the upper portion of the plant has been severed from the roots. As the cells respire, they use carbohydrates as a source of energy. Second, microorganisms consume readily available sugars and carbohydrates that are in the soluble cell contents.

When forage is severely conditioned, many cell walls are broken, killing those cells. Therefore, one would expect initial plant respiration rates to be relatively low. It is believed the increased respiration rate of the intensely conditioned material after 8 h was due to accelerated microbial growth. The sudden decline in CO_2 production after 12 h and the rise after 30 h suggest shifts in dominant microbial populations as one group exhausts one substrate and then dies while another group rises using another substrate in the plant sap.

Conclusion

Initial respiration rates of severely conditioned forage were less than those of unconditioned forage. However, 8 to 10 h after conditioning, the rate of respiration of the severely treated forage increased rapidly to approximately 2 times that of the initial rate of unconditioned forage. This increase may have been due to accelerated microbial growth. If this rate of respiration continued over an extended period of time, there may be a significant increase in carbohydrate loss due to respiration in intensively conditioned forage.

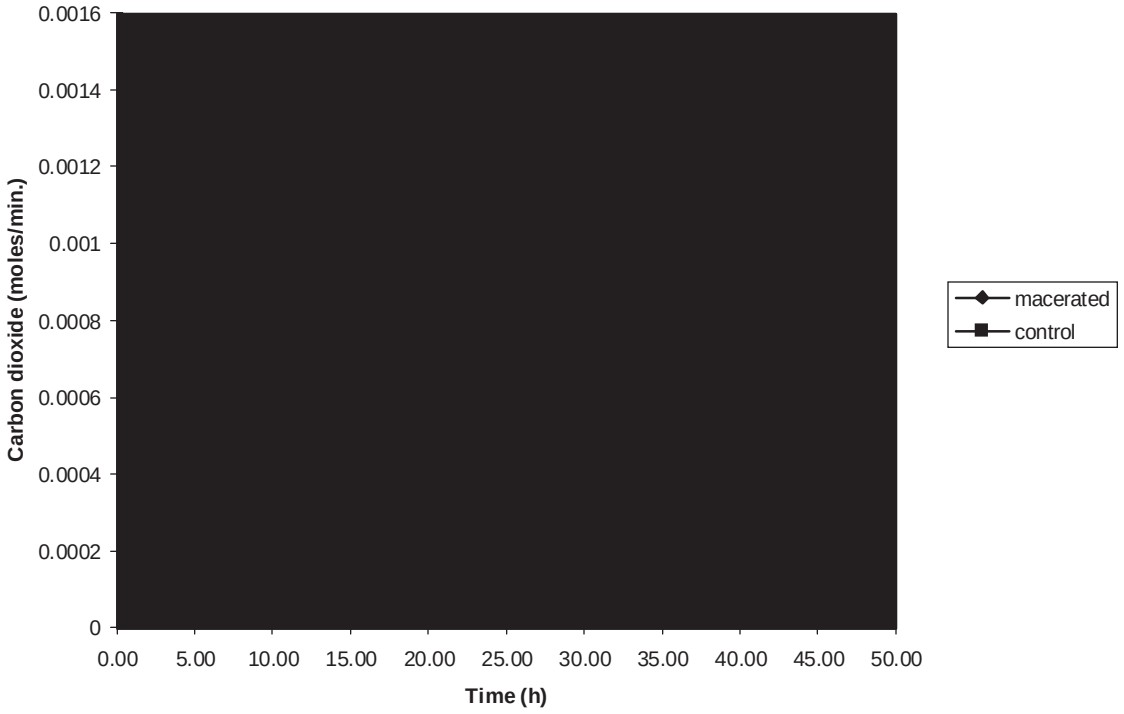

Figure 2. Carbon dioxide production from severely conditioned and unconditioned alfalfa at 31°C.